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INTERIM DEVELOPMENT REPORT

FOR

DEVELOPMENT OF LOW NOISE

TRAVELING-WAVE TUBES

RESTRICTED

This report covers the period 1 August 1961 to 31 August 1961

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Palo Alto, California

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TABLE OF CONTENTS

ABSTRACT	<u>Page</u>
I. PART I	11
A. PURPOSE	1
B. GENERAL FACTUAL DATA	1
C. DETAILED FACTUAL DATA	1
1. Solenoid Tube Testing	3
2. Broadband Match Development	6
3. Computer Studies	7
D. CONCLUSIONS	7
II. PART II: PROGRAM FOR NEXT INTERVAL	7

ILLUSTRATIONS

<u>Figure</u>	<u>Page</u>
1. Project Performance and Schedule Chart	2
2. Small-Signal Gain, Noise Figure, and Power Output Versus Frequency for the First Low-Voltage Helix L-Band Tube Tested, the M2115 No. 2.	4
3. Helix Voltage for Maximum Small-Signal Gain as a Function of Frequency.	5

ABSTRACT

The first solenoid tests of the L-band low-noise tube yielded a minimum noise figure of 5 db at 1.4 kMc and a maximum noise figure of 6 db at 1.2 to 1.8 kMc. The tube performance outside L-band was degraded by high VSWR in the input and output couplers. A cavity-type match was used which gave a VSWR less than 2:1 over the 600 Mc band; however, VSWR of less than 3:1 has been obtained using the direct connection metal-ceramic pin match with which a very low helix dispersion over the entire 1.0 to 2.6 kMc band was measured.

Further work on both the cavity-type and the direct connection pin match are required to obtain good broadband performance. A new higher voltage helix design will be tried next month which should ease the matching problem and increase the saturated power output.

TYPE I: Interim Engineering Report Number 11

DEVELOPMENT OF LOW NOISE TRAVELING-WAVE TUBES

Covering Period 1 August 1961 to 31 August 1961

Contract BuShips NObsr-81227

Index Number SS-021001/S.T.21

According to Specification MIL-R-978 (SHIPS)

I. PART I

A. PURPOSE

The purpose of this phase (Phase II) of the subject contract is to design and develop L-band PPM low noise TWT's for delivery of four final design samples.

B. GENERAL FACTUAL DATA

During the month of August, the first L-band tube was solenoid tested using the cavity-type matches; a minimum noise figure of 5 db was obtained which increased to 6 db at 1.2 and 1.8 kMc. The results are rather encouraging since this was the first tube constructed.

Construction has also been started on tubes having the higher voltage (320 volts) helix, which may be a better design from the standpoint of PPM focusing.

The other principle area of activity was in the development of the two different match designs, the cavity-type match and the metal-ceramic pin match for direct connection to the helix.

C. DETAIL FACTUAL DATA

The project performance and schedule chart is presented in Figure 1.

MICROWAVE ELECTRONICS CORPORATION

Project Performance and Schedule
Index SS-021001/S.T.21

Contract No. NObsr-81227

(Report) Date: August 1961

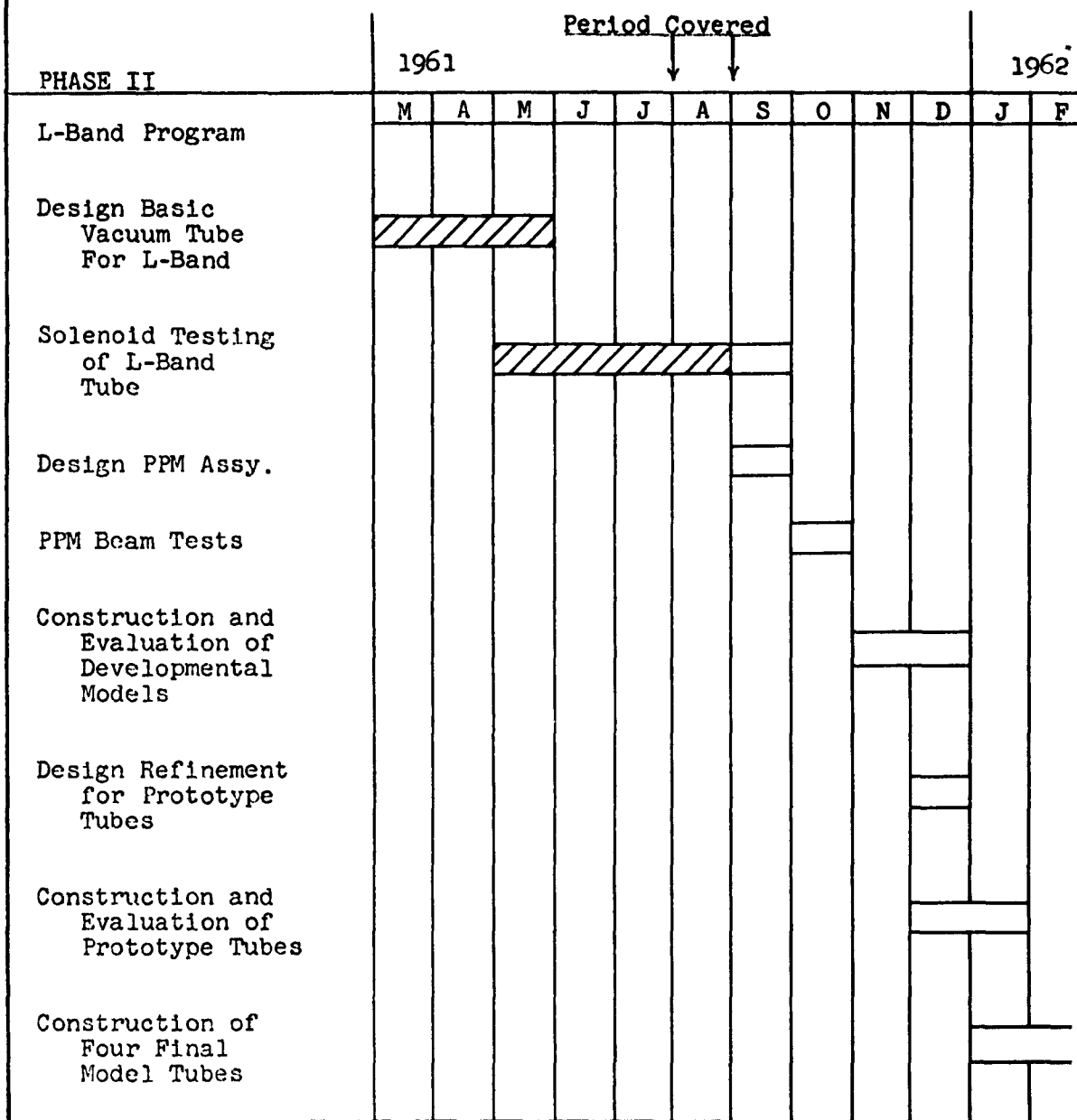


Fig. 1. Project Performance and Schedule Chart.

1. Solenoid Tube Testing

The difficulties encountered in assembling the four ceramic rod supported helices were finally overcome by obtaining a compromise in tie-wire size and barrel size. Satisfactory helices for the low-voltage (220 volts) helix design were obtained, and the first tube was built with the standard antenna and matching cylinder for use with the cavity-type match.

Because of the need to get data on the helix design, relatively little time was spent in optimizing the match. As a result, the matches were quite narrowband, and useful data could be taken only over about 600 Mc. The measured values of noise figure, small-signal gain, and saturated power output are shown in Figure 2. The maximum noise figure was 6 db, while a minimum value of 5 db was obtained. As a result, the indications are that the low-noise gun design is near optimum, at least for midband operation. The performance over the entire band remains to be seen.

The small signal gain midband is 33 db and there is considerable variation with frequency. This may be due in part to the use of the small shield diameter on the helix barrel; however, it is a little early to make any firm conclusions in this respect. The power output is low, as was expected from the low voltage helix design. However, the gain following the attenuator was low, and some improvement in output power is to be expected when the gain level and position of the attenuator is adjusted for optimum performance.

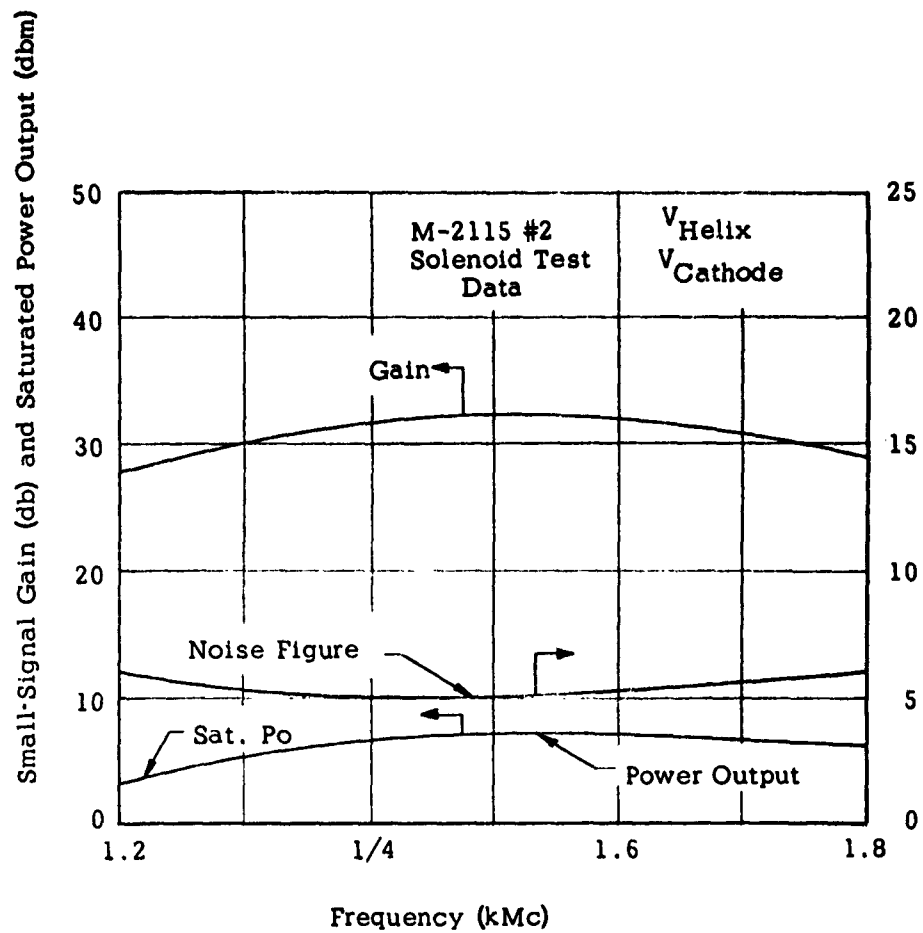


Fig. 2. Small-Signal Gain, Noise Figure, and Power Output Versus Frequency for the First Low-Voltage Helix L-Band Tube Tested, the M2115 No. 2.

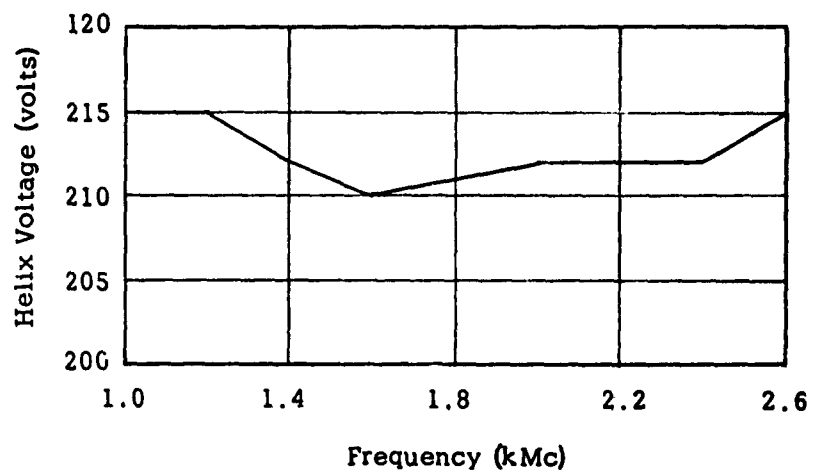


Fig. 3. Helix Voltage for Maximum Small-Signal Gain as a Function of Frequency.

The coupling to the helix outside of the band of the cavity matches was sufficient to obtain data on the variation of the synchronous velocity of the helix. The variation in helix voltage for maximum small-signal gain as a function of frequency is shown in Figure 3. The measurements indicate that the helix has very little dispersion over the entire 1.0 to 2.6 kMc frequency range.

2. Broadband Match Development

The work on development of broadband matches is continuing, using the cold test helix assemblies. The cavity-match still holds considerable promise, in spite of the expected difficulties. We have obtained matches over 50 percent of the band without using extensive impedance transformation internal to the helix structure. In the future, solenoid tubes (an extended length section of "pulled turns" on the helix) will be used to extend the bandwidth of the match.

From the standpoint of the PPM focusing structure, the "pin" match direct connection to the helix still appears to be the best solution to the match problem. A cold test helix for direct connection matching is now being used in order to evaluate the present pin match vacuum seal. Narrowband low VSWR matches tend to be quite narrowband; the best broadband performance obtained to date was a relatively flat 3 to 1 VSWR from 1.1 to 2.5 kMc. The principal problem seems to be the low impedance of the transmission line and the relatively

high impedance of the helix. The use of a greater impedance transformation on the helix structure by means of pitch tapering is planned.

3. Computer Studies

Work has been slow in getting the programs completed for using the Burroughs 220 machine at Stanford. The basic computer program has been established, and the program for computing beam trajectories is nearly completed. After this program has been checked on the computer, the noise wave equations will be programmed, using the same predictor-corrector routine.

D. CONCLUSIONS

Initial solenoid tests are encouraging, and we now have tubes available for PPM focusing tests. The solenoid tube testing program is somewhat behind schedule and will have to be continued, along with PPM testing, until adequate RF performance over the band is obtained. The decision on the use of either the cavity or pin match is being deferred until the pin match has been investigated more thoroughly.

II. PART II: Program for Next Interval

The higher voltage helix design will be evaluated in solenoid tests during the next month. Further modifications to the internal helices are required in order to reduce the helix impedance at the match and enable good broadband matches to be obtained. We do not plan to begin construction of pin match tubes for PPM testing until satisfactory matching performance is obtained. Consequently, the solenoid tests will continue, using the cavity match design which has given the best performance to date.

In order not to delay the PPM testing too long because of the lack of a pin match, we are planning to construct a PPM focusing assembly which may enable the use of cavity matches, even in the final design.

The digital program for the Burroughs 220 should be completed next month. It will then be available for use in interpreting the PPM focusing test results.